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Masaki et al.

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[54] **INTERNAL COMBUSTION ENGINE EXHAUST CLEANING METHOD AND SYSTEM**

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[52] **U.S. Cl.** .... **60/274;** 60/282; 60/285; 123/59 PC; 123/32 EA

[51] **Int. Cl.**^{2} **E02B 75/10**

[58] **Field of Search** .... 60/274, 282, 285; 123/127, 52 M, 59 PC, 32 EA

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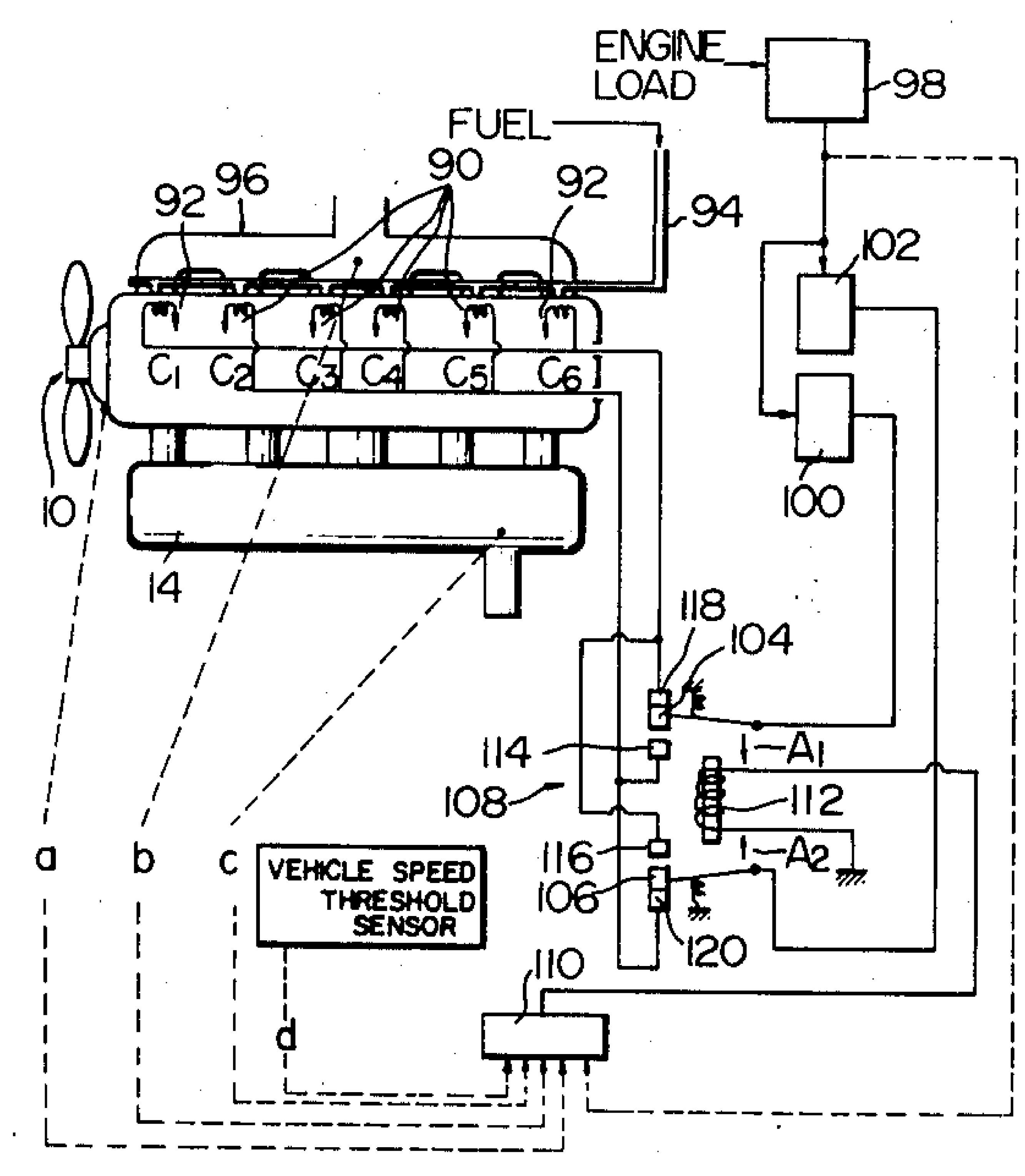
Primary Examiner—Douglas Hart

[57] **ABSTRACT**

Rich and lean air-fuel mixtures can be alternately supplied into engine cylinders in response to engine load to effectively operate an afterburner.

14 Claims, 4 Drawing Figures



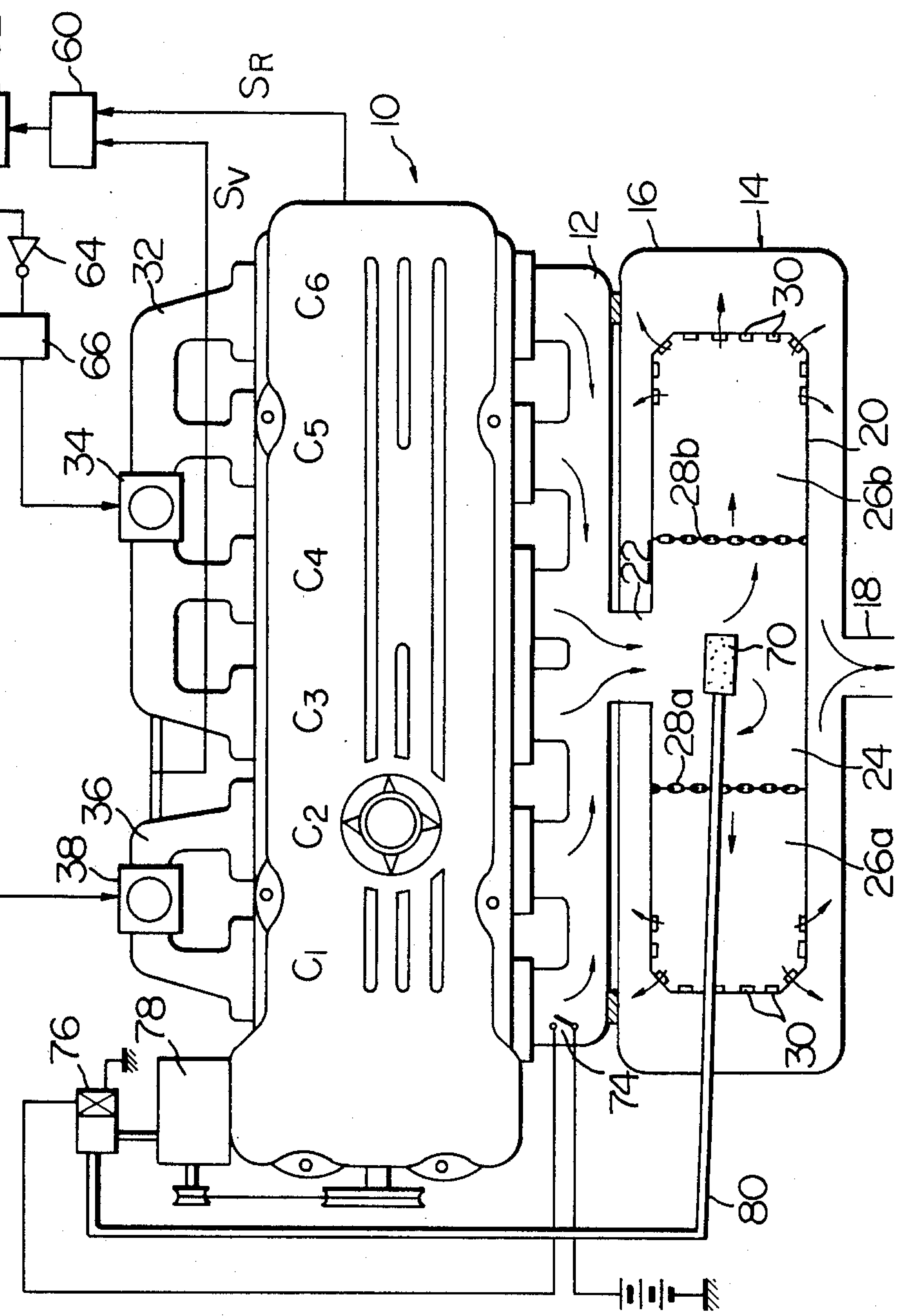


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Fig. 1

Fig. 2

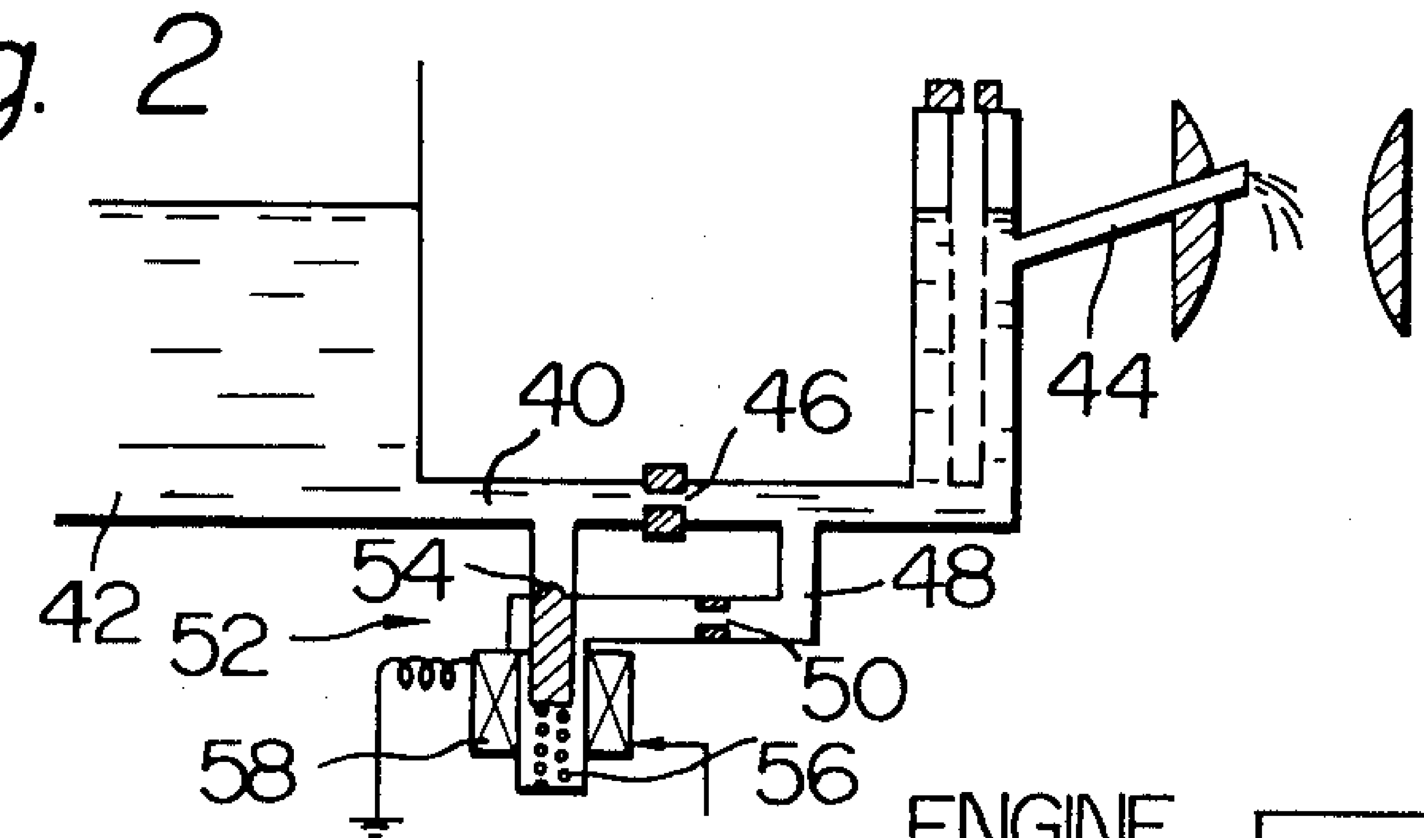
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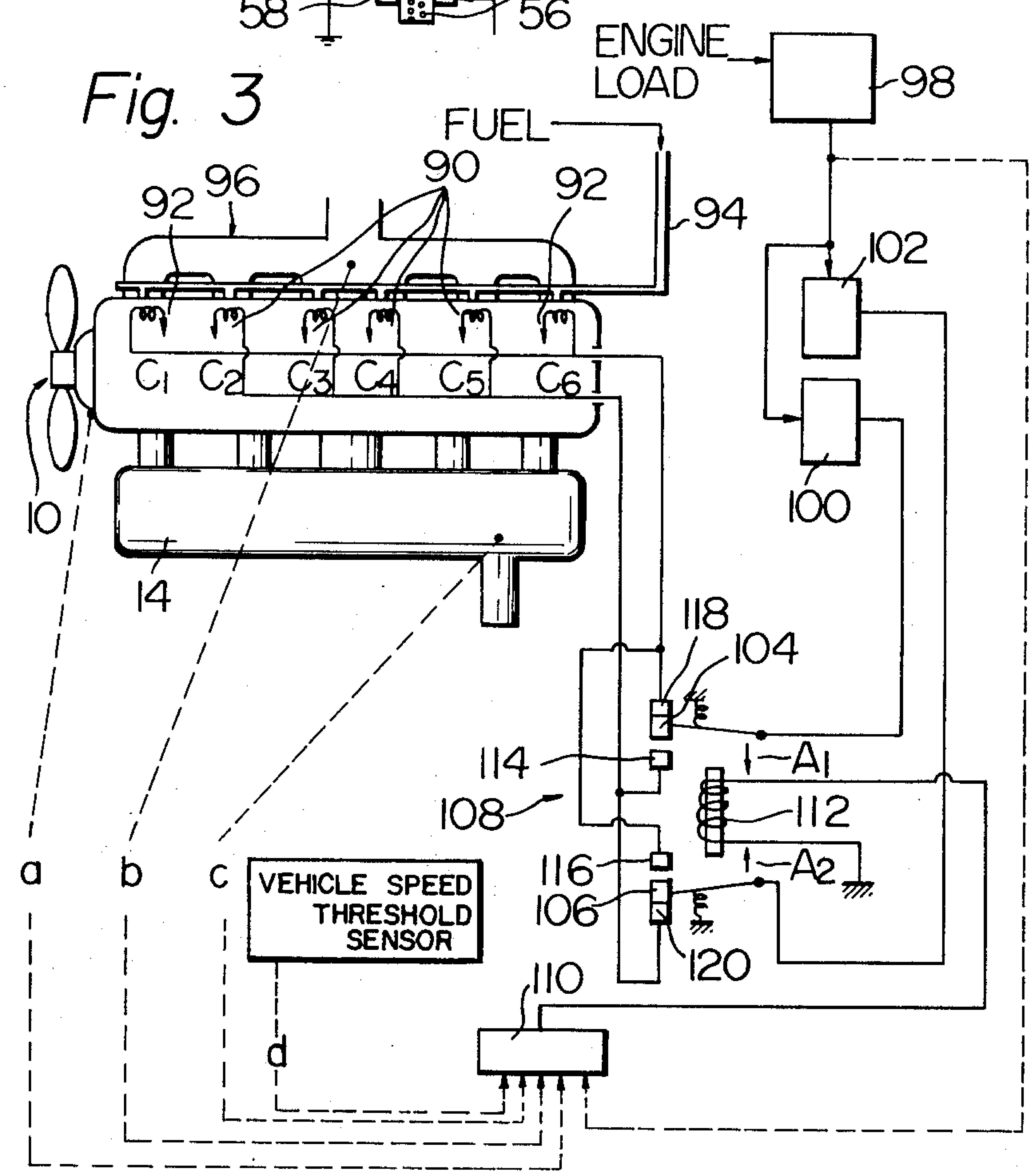
Fig. 3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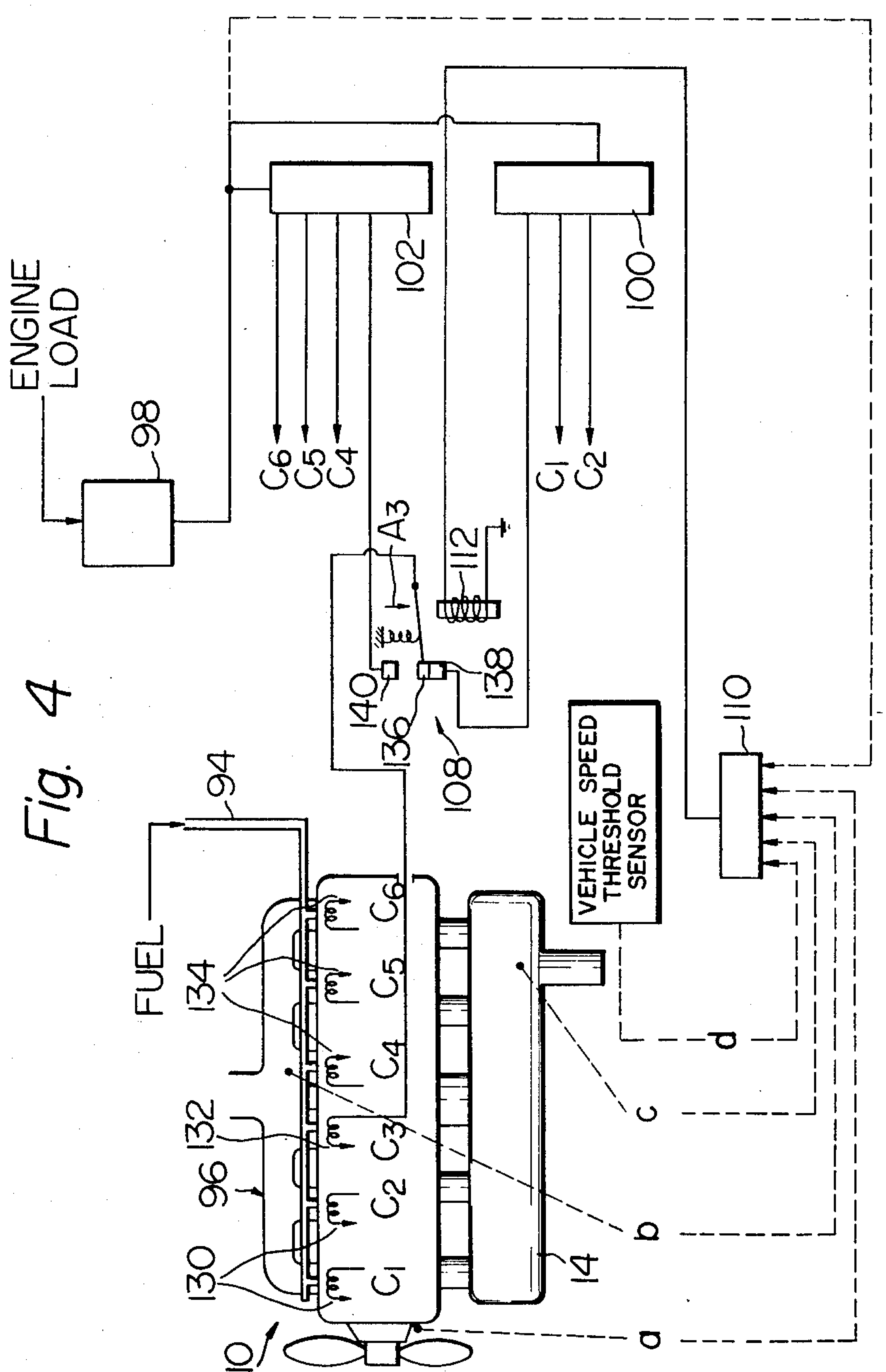
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VEHICLE SPEED THRESHOLD SENSOR
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Fig. 4

INTERNAL COMBUSTION ENGINE EXHAUST CLEANING METHOD AND SYSTEM

The present invention relates to a method of cleaning exhaust gases discharged from an internal combustion engine and a system for carrying out the method.

It is well known in the art, that the concentration of nitrogen oxides in the exhaust gases discharged from the internal combustion engine reach a peak where air and fuel mixture are combusted in the engine with the proportion of air-to-fuel ratio approximating the stoichiometric air-to-fuel ratio of 16 : 1. The concentration of nitrogen oxides thus diminish as the air-to-fuel ratios of the mixtures are at values lower or higher than the stoichiometric air-to-fuel ratio or, in other words, the mixtures are rendered richer or leaner.

It has already been proposed that a multi-cylinder internal combustion engine be operated on both a richer air-fuel mixture supplied into about half the number of total cylinders of the engine and a leaner air-fuel mixture supplied into the remaining cylinders. The exhaust gases discharged from all the engine cylinders are then introduced into an afterburning means such as an afterburner in which the gases are mixed with each other and afterburned for oxidation of harmful constituents therein.

However, in the prior art, difficulties have been encountered in that the temperature in the afterburner is not raised sufficiently high for efficient functioning and therefore gases discharged from the afterburner contain considerable amounts of harmful constituents during low load engine operation or immediately after engine starting. This results from the fact that exhaust gases introduced into the afterburner do not contain sufficient unburned constituents, e.g. carbon monoxide and hydrocarbons, which heat the afterburner by combustion within the same.

Accordingly, it is an object of the present invention to provide an improved method and system which will effectively purify exhaust gases from an internal combustion engine equipped with an afterburner by controlling the concentrations of unburned constituents contained in the exhaust gases introduced into the afterburner in response to the engine load.

It is another object of the present invention to provide an improved method and a system by which an internal combustion engine can discharge a relatively high concentration of unburned constituents and introduce them into the afterburner during low engine load operation but which can discharge a relatively low concentration of unburned constituents during medium and high load engine operations.

It is another object of the present invention to provide an improved method and a system by which the temperature in the afterburner is rapidly elevated to efficiently function during low engine load operation and prevented excessive elevation during medium and high load engine operations.

Other objects and features of the improved method and the improved system according to the present invention will become more apparent from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic view showing an example of an exhaust cleaning system according to the present invention which employs carburetors as the air-fuel mixture supply means;

FIG. 2 is a longitudinal sectional view of a carburetor employed in the system shown in FIG. 1;

FIG. 3 is a schematic view showing another example of an exhaust cleaning system according to the present invention which employs an electronically controlled fuel injection system as the fuel supply for the air-fuel mixture supply means; and

FIG. 4 is a schematic view similar to FIG. 3 but shows a further example of an exhaust cleaning system according to the present invention.

An example of an exhaust gas cleaning system which this invention consists of is illustrated in FIG. 1, the system being used for cleaning the exhaust of an internal combustion engine which is generally represented by numeral 10 and being connected thereto. The engine 10 has six cylinders C_1 to C_6 (only their locations shown) of which four cylinders C_3 to C_6 more than half the number of total cylinders, form, in this instance, a first group of cylinders while the other two cylinders C_1 and C_2 form a second group of cylinders. The exhaust ports (no numerals) of the cylinders communicate through an exhaust manifold 12 with an afterburner 14 which afterburns and purifies gases discharged from the cylinders. The afterburner 14 includes a longitudinally extending outer casing 16 having an outlet 18 for discharging purified gases into the atmosphere. In the outer casing 16 is disposed a longitudinally extending inner casing 20 having an inlet 22 connected with the exhaust manifold 12 for feeding gases from the cylinders thereinto. The inner casing 20 defines therein a mixing chamber 24 at its central portion for mixing gases discharged from the cylinders and two opposed reaction chambers 26*a* and 26*b* at its both end portions for afterburning the gases mixed in the mixing chamber 24. The chambers 24, 26*a* and 26*b* are separated from each other by two suitable porous partition walls 28*a* and 28*b*. The two reaction chambers 26*a* and 26*b* communicate through a plurality of openings 30 formed through both end portions of the inner casing 20 with a chamber defined between inner casing 20 and the outer casing 16. While a particular form of afterburner has been shown and described, other suitable afterburners may be employed if desired.

The intake ports (not shown) of the first group of engine cylinders C_3 to C_6 communicate through an intake manifold 32 with a first carburetor 34 supplying an air-fuel mixture into the cylinders while the intake ports (not shown) of the second group of cylinders C_1 and C_2 communicate through another intake manifold 36 with a carburetor 38 for supplying another air-fuel mixture into the cylinders. The first and second carburetors 34 and 38 are constructed as illustrated in FIG. 2.

As shown in FIG. 2, each of carburetors 34 and 38 includes a main fuel passage 40 which connects a float chamber 42 to a main discharge nozzle 44. The main fuel passage 40 has therein a main jet 46 which restricts the amount of fuel flowing through the passage 40. An auxiliary fuel passage 48 is disposed to connect the upstream and downstream portions of the main jet 46. In the auxiliary fuel passage 48, an auxiliary jet 50 is disposed for restricting the amount of fuel flowing through the passage 48. These carburetors 34 and 38 are such arranged as to alternately prepare a rich air-fuel mixture when fuel to be discharged from the main nozzle 44 is supplied through both the main and auxiliary fuel passages 46 and 48 and a lean air-fuel mixture when the fuel to be discharged from the main nozzle 44 is supplied through only the main fuel passage **40** with closure of the auxiliary fuel passage **48**. The rich and lean air-fuel mixtures are regulated to make a first air-fuel mixture richer than stoichiometric mixture and a second air-fuel mixture leaner than stoichiometric mixture by employing the suitable sizes of the main and auxiliary jets **46** and **50**.

Disposed in the auxiliary fuel passage **48** of each of the carburetors **34** and **38** is an electromagnetic flow control valve **52** which forms part of an actuating means for controlling the carburetors **34** and **38**. The control valve **52** is so arranged that its movable core **54** is upwardly biased by the action of a helical spring **56** to close the passage **48** when the coil **58** is de-energized and move the core **54** downwardly against the biasing force of the spring **56** to open the passage **48** when the coil **58** is energized.

The control valves **52** connected with the carburecors **34** and **38** are operated to control the air-fuel mixture supplied into the engine cylinders in accordance with the present invention in a manner illustrated hereinafter. Referring again to FIG. **1**, a load sensor **60** functions to sense an engine load signal S_v representing the intake manifold vacuum and another signal S_r representing engine speed and generate an electrical signal indicative of the two engine load signals. The signal from the load sensor **60** is transmitted to a comparator **62**. The comparator **62** alternately generates a first logic signal "0" when the signal from the load sensor **60** is below a predetermined level (during low load engine operation) and a second logic signal "1" when the signal is above the predetermined level (during medium and high load engine operations). The logic signal is transmitted to a first amplifier **66** through an inverter **64** for inverting the signal. Additionally, the logic signal is also transmitted directly to a second amplifier **68**. Accordingly, when the first logic signal "0" is transmitted from the comparator **62**, the first amplifier **66** amplifies the logic signal from the inverter **64** to produce an energizing signal S_e for energizing the electromagnetic coil **58** while the second amplifier **68** amplifies the logic signal to produce a de-energizing signal S_d for de-energizing the electromagnetic coil **58**. However, when the second logic signal "1" is transmitted from the comparator **62**, the first amplifier **66** produces a de-energizing signal S_d while the second amplifier **68** produces the energizing signal S_e. Therefore, the first carburetor **34** supplies the first air-fuel mixture into the first group of engine cylinders and the second carburetor **38** supplies the second air-fuel mixture into the second group of engine cylinders during low load engine operations. On the contrary, the first carburetor **34** supplies the second air-fuel mixture into the first group of engine cylinders and the second carburetor **38** supplies the first air-fuel mixture into the second group of engine cylinders during medium and high load engine operations.

Designated by reference numeral **70** is a secondary air injection nozzle which is adapted to supply secondary air into the mixing chamber **24** of the afterburner **14** in a following manner. When the temperature of the gases discharged from the engine **10** is relatively low, a thermo-switch **74** is closed to transmit the electric current from a battery to the solenoid cell of a valve **76** to open the valve **76**. Thus secondary air from an air pump **78** flows through the open valve **76** and a secondary air conduit **80** to the secondary air injection nozzle **70**.

As will be apparent from the above, when the ignition sequence of the engine cylinders is set at C_1–C_5–C_3–C_6–C_2–C_4, combustion sequence of the air-fuel mixtures in the engine **10** is S-F-F-F-S-F during low load engine operation while F-S-S-S-F-S during medium and high load engine operation, where F and S represent the first and second air-fuel mixtures respectively.

Thus, with this arrangement of the exhaust cleaning system, gases containing relatively high concentrations of unburned constituents are discharged from the engine **10** into the afterburner **14** and therefore the temperature in the afterburner **14** is rapidly elevated to effect function of the afterburner during low load engine operation or immediately after starting the engine. However, gases containing relatively low concentrations of unburned constituents are discharged from the engine **10** and therefore the afterburner **14** is prevented from overheating during medium and high load engine operations. Additionally, this is effective from the view point of fuel economy.

FIG. **3** illustrates another example of the exhaust gas cleaning system similar to that shown in FIG. **1** with the exception that an electronically controlled fuel injection system connected with an air induction system supplies air-fuel mixture into the engine cylinders of the engine **10**. The engine **10** has a first group of engine cylinders consisting of four engine cylinders C_2 to C_5 (only their locations shown) or more than half the number of total cylinders and a second group of engine cylinders consisting of two cylinders C_1 and C_6 (only their locations shown). The exhaust ports (no numerals) of the engine cylinders communicate through a plurality of exhaust conduits (no numerals) with an afterburner **14** similar to that shown in FIG. **1**.

The electronically controlled fuel injection system includes a first group of fuel injection devices **90** which are disposed in the intake ports (not shown) corresponding to the first group of engine cylinders C_2 to C_5 and a second group of fuel injection devices **92** which are disposed in the intake ports (not shown) corresponding to the second group of engine cylinders C_1 and C_6. Each of the fuel injection devices has, as usual, a fuel injection nozzle (not shown) for injecting fuel into the corresponding intake port and a solenoid valve (not shown) associated with the injection nozzle. The solenoid valve is, as usual, adapted to open and allow injection of pressurized fuel from a fuel conduit **94** through the injection nozzle when energized. The fuel injection device is designed in connection with the air induction system **96** to supply the first air-fuel mixture into the corresponding engine cylinder when its solenoid valve is energized for a relatively long period of time and to supply the second air-fuel mixture when its solenoid valve is energized for a relatively short period of time.

Solenoid valves of the fuel injection devices **90** and **92** are operated to control the air-fuel mixtures to be supplied into the engine cylinders in a manner illustrated hereinafter. A load sensor or an electronic computing circuit **98** is adapted to compute the required amount of fuel to be injected through the fuel injection devices **90** and **92** in accordance with the engine load using as parameters the amount of air inducted and other engine operating variables and generates an electrical signal indicative of the required amount of fuel to be injected. The signal from the computing circuit **98** is transmitted to a first pulse generator **100** for generating a first pulse signal having relatively wide pulse and to a second pulse generator **102** for generating a second pulse signal having relatively narrow pulse width. The pulse generators **100** and **102** are respectively electrically connected to a first movable contact **104** and a second movable contact **106** of an electromagnetic relay **108.**

The electrical signal from the computing circuit **98** is also transmitted to a control device **110** which is adapted to alternatively energize a coil **112** of the relay **108** when the signal from the circuit **98** is below a predetermined level and de-energize the coil **112** when the signal is above the predetermined level. The timing of energizing or de-energizing of the coil **112** may further be modified by feeding to the control device **110** signals *a*, *b*, *c* and *d* which represent respectively engine speed, intake manifold vacuum, exhaust gas temperature, and vehicle speed.

When the coil **112** of the relay **108** is energized (during low load engine operation), the movable contacts **104** and **106** are biased to the directions indicated by arrows A_1 and A_2 respectively and contact with stationary contacts **114** and **116** respectively. Accordingly, the first pulse generator **100** is connected to the solenoid valves of the first group of fuel injection devices **90** to energize their solenoid valves for a relatively long period of time in response to the first pulse signal transmitted from the first pulse generator **100** while the second pulse generator **102** is connected to the solenoid valves of the second group of fuel injection devices **92** to energize their solenoid valves for a relatively short period of time in response to the second pulse signal transmitted from the second pulse generator **102.**

On the contrary, when the coil **112** of the relay **108** is de-energized (during medium and high load engine operations), the movable contacts **104** and **106** are biased by means of springs (no numerals) and contact with stationary contacts **118** and **120** respectively. Accordingly, the first pulse generator **100** is connected to the solenoid valves of the second group of fuel injection devices **90** to energize their solenoid valves for a relatively long period of time in response to the first pulse signal while the second pulse generator **102** is connected to the solenoid valves of the first group of fuel injection devices **90** to energize their solenoid valves for a relatively short period of time in response to the second pulse signal.

In this instance, when the ignition sequence of the engine cylinders is C_1-C_5-C_3-C_6-C_2-C_4, the sequence of the air-fuel mixtures into the engine **10** is S-F-F-S-F-F during low load engine operation and F-S-S-F-S-S during medium and high load engine operations, where F and S represent the first and second air-fuel mixtures respectively.

FIG. **4** illustrates an example of an exhaust cleaning system similar to that shown in FIG. **3** with the exception that one cylinder is alternately supplied with the first or second air-fuel mixture, while two cylinders constantly receive the first air-fuel mixture and the remaining three cylinders constantly receive second air-fuel mixture. In this instance, reference numerals and characters like those in FIG. 3 designate corresponding parts, units and matters and therefore illustrations of those have been omitted for the purpose of brevity of description.

The electronically controlled fuel injection system of this example includes two fuel injection devices **130** which are disposed in the intake ports (not shown) corresponding to engine cylinders C_1 and C_2, a fuel injection device **132** which is disposed in the intake port (not shown) corresponding to an engine cylinder C_3, and three fuel injection devices **134** which are disposed in the intake ports (not shown) corresponding to engine cylinders C_4 to C_6. Each of the fuel injection devices **130, 132** and **134** is disposed similarly to that shown in FIG. **3.**

The two fuel injection devices **130** are permanently connected to the first pulse generator **100** to supply the first air-fuel mixture into the corresponding engine cylinders C_1 and C_2 while the three fuel injection devices **134** are permanently connected to the second pulse generator **102** to supply the second air-fuel mixture into the corresponding engine cylinders C_4 to C_6. However, the fuel injection device **132** is alternately connected to the first and second pulse generators **100** and **102** to alternately supply the first and second air-fuel mixtures respectively into the corresponding engine cylinder C_3 in response to the engine load.

In operation, when the coil **112** of the electromagnetic relay **108** is energized by the action of the control device **110** (during low load engine operation), a movable contact **136** connected to the fuel injection device **132** is biased to the direction of arrow A_3 against the biasing force of a spring (no numeral) so as to contact with a stationary contact **138** connected to the first pulse generator **100** and therefore the first air-fuel mixture is supplied into the engine cylinder C_3 in addition to cylinders C_1 and C_2 or half the number of total cylinders. When the coil **112** is de-energized by the action of the control device **110** (during medium and high load engine operations), the movable contact **136** is biased by the action of the spring so as to contact with a stationary contact **140** connected to the second pulse generator **102** and therefore the second air-fuel mixture is supplied into the engine cylinder C_3 in addition to cylinders C_4 to C_6.

In this instance, when ignition sequence of the engine cylinders is set at C_1-C_5-C_3-C_6-C_2-C_4, combustion sequence of the air-fuel mixtures in the engine **10** is F-S-S-S-F-S during low load engine operation while it is F-S-F-S-F-S during medium and high load engine operations.

It will be noted that the exhaust cleaning system shown in FIG. **4** is particularly suitable for a stationary internal combustion engine because such a type is mainly operated at medium and high engine loads and stopped infrequently.

Thus, with this arrangement of the exhaust cleaning system shown in FIG. **4,** exhaust gases capable of being burned are discharged from the engine **10** into the afterburner **14** during low load engine operation, while gases containing relatively low concentration of the unburned constituents are discharged from the engine **10** and therefore the afterburner **14** is prevented from an excessive rise of the temperature therewithin.

What is claimed is:

1. A method of cleaning exhaust gases from a multicylinder internal combustion engine comprising the steps of:

supplying a first air-fuel mixture richer than stoichiometric mixture into engine cylinders consisting of at least half the number of total cylinders of the engine and a second air-fuel mixture leaner than stoichiometric mixture into the remaining cylinders of the engine during low load engine operation;

supplying the second air-fuel mixture into engine cylinders consisting of more than half the number of total engine cylinders and the first air-fuel mixture into the said remaining engine cylinders during medium and high load engine operation; and

afterburning in an afterburner the gases discharged from all the engine cylinders;

whereby the temperature in the afterburner is elevated so that the afterburner effectively functions during low load engine operation, while the temperature is prevented from excessive elevation during medium and high load engine operation.

2. A method of cleaning exhaust gases from a multicylinder internal combustion engine comprising the steps of:

supplying a first air-fuel mixture richer than stoichiometric mixture into a first group of engine cylinders consisting of more than half the number of total cylinders of the engine and a second air-fuel mixture leaner than stoichiometric mixture into a second group of engine cylinders consisting of the remaining cylinders of the engine during low load engine operation;

supplying the first air-fuel mixture into the second group of engine cylinders and the second air-fuei mixture into the first group of engine cylinders during medium and high load engine operation; and

afterburning in an afterburner the gases discharged from all the engine cylinders;

whereby the temperature in the reburning means is rapidly elevated so that the reburning means effectively functions during the low load engine operation, while the temperature is prevented from excessive elevation during medium and high load engine operation.

3. In a multicylinder internal combustion engine equipped with afterburner for afterburning gases from all the engine cylinders of the engine, the system comprising:

air-fuel mixture supply means for supplying air-fuel mixture into the engine cylinders;

actuating means operative to alternately take a first state in which said air-fuel mixture supply means supply a first air-fuel mixture richer than stoichiometric mixture into engine cylinders consisting of at least half the number of total engine cylinders and a second air-fuel mixture leaner than stoichiometric mixture into the remaining engine cylinders, and a second state in which said air-fuel mixture supply means supply the second air-fuel mixture into engine cylinders consisting of more than half the number of total engine cylinders and the first air-fuel mixture into the remaining engine cylinders; and

control means for alternately generating a first signal during low load engine operation to put said actuating means into the first state and a second signal during medium and high load engine operations to put said actuating means into the second state;

whereby the engine discharges gases containing relatively high concentration of unburned constituents and thereafter the gases are introduced into the afterburner during low load engine operation so that the temperature in the afterburner is rapidly elevated to function effectively, while the engine discharges gases containing relatively low concentration of the unburned constituents and thereafter the gases are introduced into the afterburner during medium and high load engine operation so that the temperature is prevented from its excessive elevation.

4. In a multicylinder internal combustion engine having a first group of engine cylinders consisting of more than about half the number of total cylinders and a second group of engine cylinders consisting of remaining cylinders, equipped with afterburner for afterburning gases discharged from all the engine cylinders, the system comprising:

first and second air-fuel mixture supply means for supplying air-fuel mixture into the first and second groups of engine cylinders respectively;

actuating means operative to alternately take a first state in which said first air-fuel supply means supply a first air-fuel mixture richer than stoichiometric mixture and said second air-fuel supply means supply a second air-fuel mixture leaner than stoichiometric mixture, and a second state in which said first air-fuel supply means supply the second air-fuel mixture and said second air-fuel supply means supply the second air-fuel mixture; and

control means for alternately generating a first signal during low load engine operation to put said actuating means into the first state and a second signal during medium and high load engine operations to put said actuating means into the second state;

whereby the engine discharges gases containing relatively high concentration of unburned constituents and thereafter the gases are introduced into the afterburner during low load engine operation so that the temperature in the afterburner is rapidly elevated to function effectively, while the engine discharges gases containing relatively low concentration of the unburned constituents and thereafter the gases are introduced into the afterburner during medium and high load engine operations so that the temperature is prevented from excessive elevation.

5. A system as claimed in claim 4, in which said first and second air-fuel mixture supply means include first and second carburetors, each of said carburetors including a main fuel passage connecting a float chamber to a main discharge nozzle and having a main jet therein, and an auxiliary fuel passage connecting upstream and downstream portions of the main jet in the main fuel passage and having an auxiliary jet therein.

6. A system as claimed in claim 5, in which said actuating means includes first and second electromagnetic flow control valves respectively combined with said first and second carburetors, each of said valves being operative to alternately be energized and de-energized to open and close respectively said auxiliary fuel passage of the corresponding carburetor in response to signals transmitted from said control means, and an inverter electrically connected to said first valve for inverting the signal transmitted from said control means.

7. A system as claimed in claim 6, further including a first amplifier electrically connecting said first flow control valve and said inverter, and a second amplifier electrically connected to said second flow control valve.

8. A system as claimed in claim 6, in which said control means includes a load sensor for sensing the engine load and generating an electrical signal responsive to the engine load, and a comparator electrically connect-

ing said load sensor to the inverter and the second flow control valve of said actuating means and adapted to alternately generate a first logic signal for energizing solenoid valves of said actuating means when the electrical signal from the load sensor is lower than a predetermined level and a second logic signal for energizing the solenoid valves when the electrical signal is higher than the predetermined level.

9. A system as claimed in claim **4,** in which said first and second air-fuel mixture supply means include a first and second group of fuel injection devices, each of said devices including a fuel injection nozzle for respectively injecting fuel into the intake port of the corresponding engine cylinder, and a solenoid valve controlling the flow to said corresponding nozzle.

10. A system as claimed in claim **9,** in which said actuating means includes a first pulse generator for generating a pulse signal having relatively wide pulse width, a second pulse generator for generating another pulse signal having relatively narrow pulse width, and an electromagnetic relay operative to alternately connect said first pulse generator to said first air-fuel supply means and said second pulse generator to said second air-fuel supply means when the electromagnetic coil of said relay is energized, while connecting said first pulse generator to said second air-fuel supply means and said second pulse generator to said first air-fuel supply means when the electromagnetic coil is de-energized.

11. A system as claimed in claim **10,** in which said control means includes an electronic computing circuit adapted to generate and transmit a signal responsive to the engine load to said first and second pulse generators for changing the pulse width of the pulse signal generated by said pulse generators in response to the signal from said computing circuit, and a control device electrically connecting to said electronic computing circuit and adapted to alternately generate the first signal for energizing the electromagnetic coil of said electromagnetic relay when the signal from said computing circuit is below a predetermined level while the second signal de-energizes said coil when the signal from the circuit is above the predetermined level.

12. A system as claimed in claim **3,** in which said air-fuel mixture supply means further includes a first group of fuel injection devices for supplying fuel into a first group of engine cylinders consisting of less than half the number of total cylinders, a second group of fuel injection devices for supplying fuel into a certain number of engine cylinders and a third group of fuel injection devices for supplying fuel into engine cylinders consisting of about half the number of total engine cylinders, each of said devices having a fuel injection nozzle for injecting fuel into the corresponding intake port of said cylinder, and a solenoid valve controlling its corresponding nozzle.

13. A system as claimed in claim **12,** in which said actuating means includes a first pulse generator for generating a pulse signal having a relatively wide pulse width electrically connecting to solenoid valves of said first group of fuel injection devices, a second pulse generator for generating another pulse signal having a relatively narrow pulse width electrically connected to the solenoid valves of said third group of fuel injection devices and an electromagnetic relay operative to alternately connect said first pulse generator to said second group of fuel injection devices when the coil of said relay is energized while connecting said second pulse generator to the second group of fuel injection devices when the coil of the relay is de-energized.

14. A system as claimed in claim **13,** in which said control means includes an electronic computing circuit adapted to generate and transmit a signal responsive to the engine load to said first and second pulse generators for changing the pulse width of the pulse signal generated by said pulse generators in response to the signal from said computing circuit, and a control device electrically connected to said computing circuit and adapted alternately to generate the first signal for energizing the coil of said electromagnetic relay when the signal from said computing circuit is below a predetermined level while the second signal de-energizes the coil when the signal from said computing circuit is above said predetermined level.

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